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Comparative analysis of the performance of male and female students in physics for the West African examination council examination in Zuarungu senior high school in the Upper East Region, Ghana

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Abstract
This study conducted a comparative analysis of the performance of male and female students in physics at the West African Examination Council (WAEC) examination scores over five years in Zuarungu Senior High School in the Upper East Region of Ghana with a sample size of 419. Historical data was obtained from Zuarungu Senior High School, and statistical analysis was conducted using SPSS version 26.0.
The findings revealed fluctuations in performance trends over the years, with females generally showing a slightly higher count in the A1-C6 and D7-E8 grade categories, while males had a higher count in the F9 grade category. These disparities underscore the need for targeted interventions to promote gender equity in physics education. Recommendations include implementing gender-sensitive teaching practices, promoting diverse role models, and creating inclusive learning environments.
Overall, the study contributes to the existing literature on gender differences in physics performance and provides insights for educators and policymakers to address these disparities effectively.

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Introduction

The field of science, technology, engineering, and mathematics (STEM) education has long been subject to gender-based disparities, with studies indicating variations in the academic performance of male and female students in these disciplines (Archer *et al*., 2012; Hyde *et al*., 2019) [1, 16]. Within this broader context, physics, a fundamental branch of STEM, has been observed to exhibit notable gender imbalances, both in terms of enrollment and performance outcomes (Brewe *et al*., 2010; Bursal & Paznokas, 2006) [2, 4]. In the Upper East Region of Ghana, where the West African Examination Council (WAEC) plays a pivotal role in assessing students' academic achievements, there exists a unique educational landscape shaped by cultural, social, and economic factors. While strides have been made in enhancing educational opportunities for both genders, questions persist about the extent of gender-based disparities in physics performance, particularly within the confines of the WAEC examination. Understanding the background of these disparities is crucial for devising targeted interventions that promote equality in educational outcomes.

Historically, gender-based disparities in STEM education have been attributed to a myriad of factors, including societal expectations, stereotypes, and cultural norms (Archer *et al*., 2012) [1]. In Ghana, traditional gender roles have influenced the educational choices and opportunities available to male and female students, contributing to the perpetuation of gender imbalances in certain subjects, such as physics. Additionally, the scarcity of female role models in the field of physics may influence young girls' aspirations and confidence in pursuing this discipline (Blickenstaff, 2005) [3].

Furthermore, studies suggest that classroom dynamics and teaching methodologies can impact students' performance in physics, with potential differences in how male and female students engage with the material (Brewe *et al*., 2010; Perez *et al*., 2014) [2, 24]. Understanding these nuances is vital for tailoring teaching approaches that cater to the diverse learning styles and preferences of both genders.

Against this backdrop, this study delves into the specific context of the Upper East Region in Ghana, seeking to uncover the root causes of gender-based disparities in physics performance at the WAEC examination. By examining historical trends, societal expectations, and classroom dynamics, the research aims to provide a comprehensive understanding of the background factors contributing to the observed differences in academic achievement between male and female students. This will significantly provide informed evidence-based interventions and strategies aimed at promoting gender equality in physics education.

Statement of the Problem

Gender-based disparities in educational outcomes, particularly in the domain of physics, remain a persistent challenge globally, transcending geographical boundaries (Archer *et al*., 2012; Bursal & Paznokas, 2006) [1, 4]. The Zuarungu Senior High School of the Upper East Region of Ghana is no exception, where the West African Examination Council (WAEC) examination serves as a critical benchmark for assessing students' academic achievements. Despite efforts to enhance gender equality in education, a notable gap persists in the performance of male and female students in physics at the WAEC examination.

The crux of the problem lies in the observed disparities in the scores attained by male and female students in physics, raising critical questions about the factors contributing to this gap. Historically, studies have highlighted societal expectations and cultural norms as influential factors shaping gender roles and educational choices (Archer *et al*., 2012) [1]. In the Ghanaian context, these factors may contribute to the perpetuation of stereotypes and biases that influence students' aspirations and performance in physics.

While existing literature acknowledges the broader issue of gender-based disparities in STEM education, there is a paucity of research specifically examining the nuances of this problem within the Upper East Region of Ghana.

Moreover, the impact of classroom dynamics and teaching methodologies on the performance of male and female students in physics has been a subject of scholarly inquiry (Brewe *et al*., 2010; Perez *et al*., 2014) [2, 24]. However, the extent to which these factors contribute to the observed disparities in the Upper East Region remains unclear. Addressing this gap is crucial for designing targeted interventions that enhance the learning experience and outcomes for both genders in physics education.

The statement of the problem underscores the urgency and significance of investigating the performance disparities between male and female students in physics at the WAEC examination in the Zuarungu Senior High School in the Upper East Region. By identifying the root causes of these disparities, policymakers, educators, and stakeholders can develop informed strategies to promote gender equality in physics education, fostering an inclusive and equitable learning environment for all students.

Research objectives

The following were the objectives the research seeks to answer.

1. To determine historical trends in the performance of Zuarungu Senior High School students in physics at the WAEC examination at Zuarungu Senior High School in the Upper East Region, and how have these trends evolved over time.
2. To compare the differences in performance of male and female students of physics at the WASSCE in Zuarungu Senior High School in the upper East region of Ghana.

Literature Review

Enrollment Disparities

Historically, women have been underrepresented in STEM fields both at the educational and professional levels (Ceci *et al*., 2014; Wang & Degol, 2017) [5]. The phenomenon of fewer women pursuing STEM disciplines begins early in the educational pipeline, with studies indicating lower enrollment rates in STEM-related courses and programs at the secondary and tertiary levels (Blickenstaff, 2005; Hill *et al*., 2010) [3, 10]. This initial underrepresentation sets the stage for the gender gap observed in STEM careers. While enrollment disparities exist, research suggests that the academic performance of female students in STEM subjects is often comparable to or even surpasses that of their male counterparts. Despite demonstrating equal or superior abilities, female students may face barriers to advancing their STEM education and careers, pointing to systemic issues that extend beyond individual capabilities Disparities Among Male and Female Students in Physics Performance

Gender disparities in physics performance have been the subject of extensive research, with investigations into the factors that contribute to differential academic outcomes between male and female students. This section delves into the existing literature on disparities among male and female students in physics performance, exploring various dimensions of the issue.

Examining exam scores

Studies examining examination scores often reveal variations in physics performance between male and female students. While some research suggests no significant gender differences in physics achievement (Hazari *et al*., 2017; Nosek *et al*., 2009) [22], other studies point to subtle disparities, with male students sometimes outperforming their female counterparts (Lindberg *et al*., 2010) [20]. These disparities may manifest in different regions and educational systems, prompting a need for localized investigations.

Classroom dynamics and teaching approaches

The dynamics within physics classrooms play a pivotal role in shaping the learning experiences and outcomes of male and female students. Research indicates that factors such as teacher- student interactions, pedagogical methods, and classroom environments can impact performance (Brewe *et al*., 2010; Perez *et al*., 2014) [2, 24]. Gender-sensitive teaching approaches that address diverse learning styles and preferences are crucial for fostering equitable outcomes. Classroom dynamics and teaching practices can inadvertently

contribute to gender disparities in STEM education. Studies indicate that subtle biases, such as the "mathematics myth" suggesting innate gender differences in mathematical abilities, may affect teacher expectations and student outcomes (Spencer *et al*., 1999; Nosek *et al*., 2009) [22, 26]. Creating inclusive and supportive learning environments is crucial for mitigating these biases.

Societal Expectations and Stereotypes

Societal expectations and stereotypes contribute to the disparities observed in physics performance. Traditional gender roles and stereotypes about innate abilities in science subjects may influence students' self-perceptions and confidence in pursuing physics (Archer *et al*., 2012; Blickenstaff, 2005) [1, 3]. The gender disparities observed in STEM education extend into professional settings, impacting career advancement and workforce representation. Women continue to be underrepresented in STEM occupations, particularly in leadership roles (Hill *et al*., 2010; National Science Foundation, 2019) [10, 15]. Persistent challenges related to workplace culture, bias, and family-work balance contribute to the retention gap for women in STEM careers.

Addressing these societal influences is vital for creating an inclusive environment that encourages all students to engage in physics education. Societal perceptions and stereotypes play a significant role in shaping the choices and experiences of individuals in STEM fields. Traditional gender norms and expectations may influence students' self-perceptions and career aspirations (Eccles, 2007; Charles & Bradley, 2009) [9, 6]. The persistent belief that certain STEM disciplines are more suited to males contributes to the perpetuation of gender disparities.

Confidence and Self-Efficacy

Studies have explored the link between confidence, self-efficacy, and physics performance, revealing potential gender differences. Research suggests that male students may exhibit higher levels of confidence and self-efficacy in physics, which can impact their engagement and persistence in the subject (Osborne *et al*., 2003) [23]. Fostering confidence-building strategies is crucial for narrowing the gender gap in physics achievement.

Role of Role Models

The scarcity of female role models in physics has been identified as contributing to gender disparities. Lack of representation may impact female students' aspirations and confidence in pursuing physics-related careers (Hazari *et al*., 2017; Lock & Hazari, 2019) [19]. Efforts to promote diverse role models and highlight successful female physicists can positively influence students' perceptions.

Factors Influencing Physics Performance

The academic performance of students in physics is influenced by a myriad of factors, encompassing individual, social, and educational dimensions. Understanding these factors is essential for devising targeted interventions to address disparities among male and female students in physics performance. This section explores the existing literature on the diverse factors that influence physics performance.

Individual Factors

Individual factors encompass aspects related to the student's personal characteristics, cognitive abilities, and motivation. Studies suggest that individual interest and intrinsic motivation positively correlate with physics performance. Cognitive abilities, including mathematical aptitude and spatial reasoning, also play a role in shaping performance outcomes. These individual factors interact with gender dynamics, influencing how male and female students engage with physics content.

Teacher Quality and Classroom Dynamics

The quality of teaching and classroom dynamics significantly influences physics performance. Effective teaching strategies, supportive learning environments, and engaging classroom activities contribute to positive outcomes (Hake, 1998; Freeman *et al*., 2014) [13]. Teacher-student interactions, feedback mechanisms, and the overall classroom climate impact the academic experiences of both male and female students (Brewe *et al*., 2010) [2].

Pedagogical Approaches:

The choice of pedagogical approaches and instructional methods is a critical factor in physics education. Active learning strategies, hands-on experiments, and inquiry-based learning have been associated with improved student performance and engagement (Deslauriers *et al*., 2019; Freeman *et al*., 2014) [13]. The effectiveness of these approaches may vary based on gender, highlighting the importance of tailoring teaching methods to address diverse learning styles.

Socioeconomic Background

Socioeconomic factors, including family income and parental education, can influence physics performance. Students from economically disadvantaged backgrounds may face additional challenges, such as limited access to educational resources and extracurricular opportunities (Sirin, 2005; Davis-Kean, 2005) [7, 25]. Understanding the socioeconomic context is crucial for developing equitable educational policies and support mechanisms.

Role of Peer Influence

Peer interactions and group dynamics within the classroom can impact physics performance. Studies suggest that positive peer relationships and collaborative learning experiences contribute to a supportive learning environment (Springer *et al*., 1999; Freeman *et al*., 2014) [13]. Peer influence may affect both male and female students differently, necessitating an examination of gender dynamics within collaborative settings.

Parental Expectations and Support

Parental expectations and support play a significant role in shaping students' attitudes toward physics. Research indicates that parental involvement, encouragement, and expectations positively correlate with academic achievement (Fan & Chen, 2001; Jeynes, 2007) [12, 18]. Gendered expectations within families may contribute to divergent experiences for male and female students, impacting their physics performance.

Cultural and Societal Influences

Cultural and societal influences, including norms, values, and stereotypes, contribute to the gendered dynamics in physics education. Studies highlight the impact of cultural beliefs

about gender roles and abilities on students' self-perceptions and career aspirations in physics (Hazari *et al*., 2017; Archer *et al*., 2012) [1]. Culturally sensitive interventions are essential for challenging stereotypes and fostering an inclusive learning environment.

Accessibility of Resources

The availability of resources, including textbooks, laboratory equipment, and technology, can impact physics performance. Disparities in resource allocation may contribute to unequal learning opportunities (Hazari *et al*., 2017; Sirin, 2005) [25]. Ensuring equitable access to resources is vital for creating a level playing field for both male and female students.

Societal Expectations and Gender Roles: Impact on Physics Performance

Societal expectations and entrenched gender roles play a profound role in shaping the experiences and performance of male and female students in physics education. The impact of cultural and societal influences on academic outcomes has been a focal point of research, unveiling how gender stereotypes and expectations manifest within educational contexts.

Previous Studies on Gender Disparities in Physics Performance

A wealth of previous studies has sought to unravel the complexities of gender disparities in physics performance, examining various dimensions including academic achievement, classroom dynamics, and societal influences. These investigations provide critical insights into the factors contributing to the observed differences between male and female students in physics education.

Previous research on academic achievement in physics has yielded mixed findings. Some studies report no significant gender differences in physics performance, suggesting that male and female students achieve comparable scores on examinations (Hazari *et al*., 2017; Nosek *et al*., 2009) [22]. However, other research indicates subtle variations, with male students occasionally outperforming their female counterparts (Lindberg *et al*., 2010) [20]. These variations may be influenced by diverse factors, necessitating a nuanced examination.

The role of classroom dynamics and teaching approaches in perpetuating or mitigating gender disparities have been a focus of scholarly inquiry. Studies highlight the impact of teacher-student interactions, pedagogical methods, and classroom environments on the engagement and performance of male and female students in physics (Brewe *et al*., 2010; Perez *et al*., 2014) [2, 24]. Collaborative and inclusive teaching practices have been associated with positive outcomes for both genders, emphasizing the need for gender-sensitive instructional strategies.

Research exploring the influence of societal expectations and stereotypes on gender disparities in physics performance has shed light on the pervasive nature of these influences. Studies emphasize the impact of gendered expectations on students' self-perceptions, confidence levels, and aspirations in physics education (Archer *et al*., 2012; Blickenstaff, 2005) [1, 3]. Understanding the interplay between societal norms and academic outcomes is crucial for developing interventions that challenge stereotypes and promote inclusivity.

The relationship between confidence, self-efficacy, and physics performance has been a subject of investigation. Research suggests that male students often exhibit higher levels of confidence and self-efficacy in physics, potentially influencing their persistence and engagement (Osborne *et al*., 2003) [23]. Addressing these confidence gaps is imperative for creating a supportive learning environment that empowers all students.

The scarcity of female role models in physics has been a recurring theme in the literature. Studies emphasize the importance of representation and visibility in shaping students' aspirations and sense of belonging in physics education. Positive representations of successful female physicists can serve as catalysts for challenging gender norms and inspiring female students to pursue physics-related careers.

The exploration of intersectionality within physics education has gained prominence. Research acknowledges that gender disparities intersect with other identity dimensions, such as race and socioeconomic status, creating unique challenges for individuals who belong to multiple marginalized groups (Eddy *et al*., 2014; Jones & Scherz, 2019). An intersectional approach is essential for understanding the nuanced experiences of diverse student populations.

Previous studies contribute valuable insights to the formulation of evidence-based educational policies and interventions. Recommendations include the implementation of gender-sensitive teaching practices, the promotion of diverse role models, and the cultivation of inclusive learning environments that challenge stereotypes (Hazari *et al*., 2017; Lock & Hazari, 2019) [19]. These recommendations aim to address the multifaceted nature of gender disparities in physics performance.

Research Methodology

Research Approach

The research employed a quantitative research approach. This design allowed for a comprehensive exploration of the research questions, with statistical analysis of examination of both WASSCE scores. This study employed a quantitative research design to analyze the performance of male and female students in physics at the West African Examination Council

(WAEC) examination in the Upper East Region of Ghana. The primary aim was to identify statistically significant differences in examination scores between male and female students and the performance of students in Zuarungu Senior High School in physics.

Participants and Sampling

The study involved collecting secondary data on secondary school students' WASSCE performance in physics at Zuarungu Senior High School of the Upper East Region.

Data Collection

The quantitative component involved the analysis of WAEC examination scores over five years. Historical data was obtained from Zuarungu Senior High School in the Upper East Region of Ghana. anonymized to protect student privacy. Comparative analysis was conducted to examine trends in the performance of male and female students in physics at Zuarungu Senior High School.

Data Analysis

Descriptive statistics were used to analyze overall performance trends. Mean scores, standard deviations, and

percentiles were calculated to describe the overall performance. Inferential statistics (t-tests) were applied to compare mean scores between male and female students and the mean performance of students' WASSCE physics results. Data analysis was conducted using statistical software such as SPSS (Statistical Package for the Social Sciences) version 26.0 was used. The use of statistical software ensured accuracy, efficiency, and the ability to handle large datasets.

Population and Sample Size

The population for this quantitative study consisted of all senior secondary school physics students who took the WAEC physics examination in Zuarungu Senior High School over the last five years with a sample size of 419. The study covered both male and female students in the schools.

Data Source

The primary source of data for this study was the West African Examination Council (WAEC). The WAEC database holds records of examination scores for students who participated in the physics examinations in the specified region during the specified timeframe.

Results and Discussion

Figure 1 presents the results that indicate historical trends in the performance of students in physics at the WAEC examination in Zuarungu Senior High School in the Upper East Region, how have these trends evolved over time?

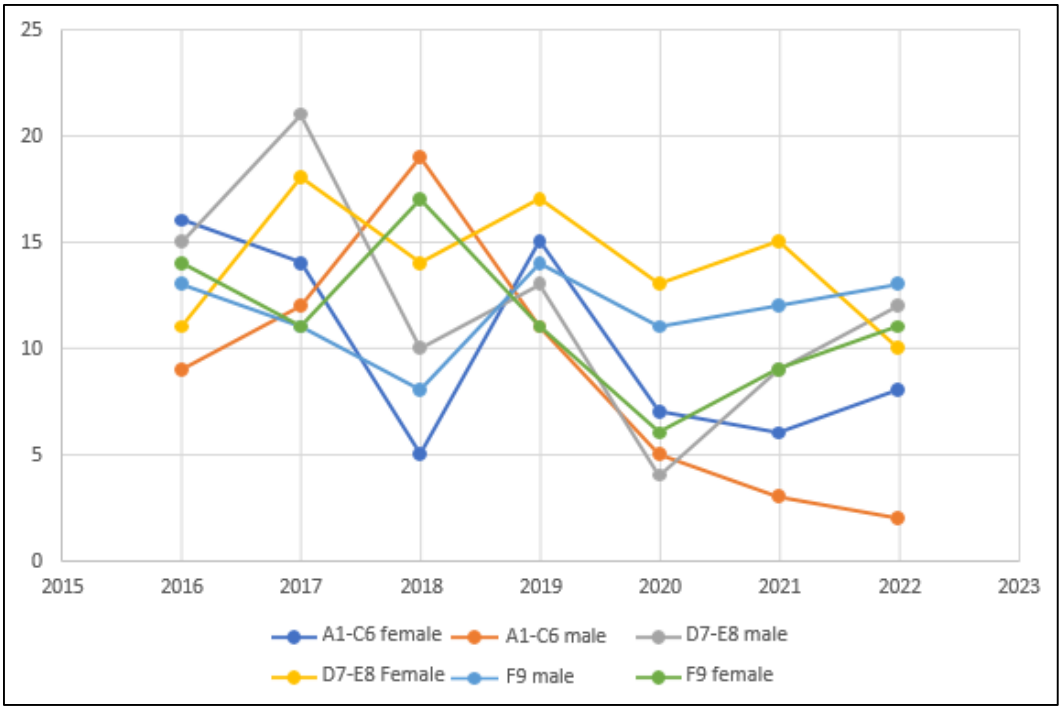

Fig 1: Historical trends in the performance of students in physics at the WAEC examination in Zuarungu Senior High School

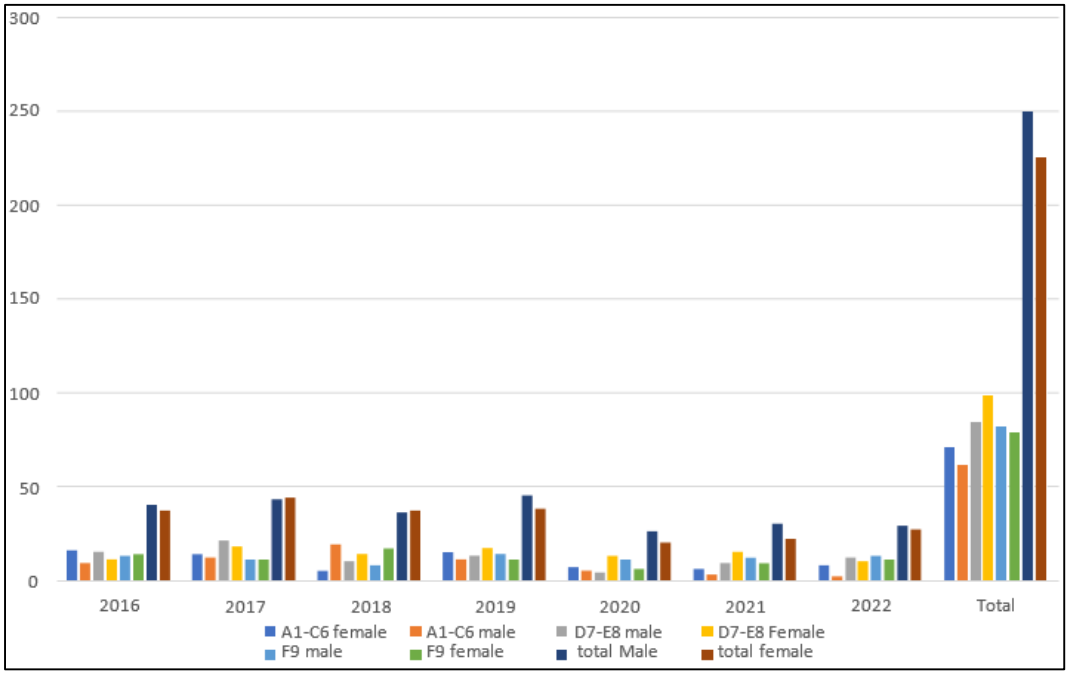

Fig 2: Differences in performance of male and female students of physics in the WASSCE at Zuarungu Senior High School

Figure 2 shows data on the academic performance of male and female students in three grade categories (A1-C6, D7-E8, F9) over the years 2016-2022 and the overall performance

From Figure 2, the A1-C6 Grade Category indicates that the total count of females in this grade category is 71, indicating a consistent performance level over the years. Females have a slightly higher count compared to males (61), suggesting a marginally better performance. Males have a lower count than females in this grade category, indicating that they may be performing slightly lower than females. However, the difference is not significant.

However, the D7-E8 Grade Category also shows that females have a total count of 98 in this grade category, which is higher than males (84). This suggests that females may be performing slightly better than males in this category. In contrast, the males have a lower count than females, indicating potentially lower performance. However, the difference is not substantial.

Furthermore, the F9 Grade Category also indicated that the total count of females in this grade category is 79, slightly lower than males (82). This suggests that females may be performing slightly lower than males in this category while males have a slightly higher count than females, indicating potentially better performance. However, the difference is not significant.

Finally, overall trends of the performance show that, females generally have a higher total count in the A1-C6 and D7-E8 grade categories, suggesting potentially better performance in these categories while the male students have a higher total count in the F9 grade category, indicating potential better performance in this category of the female than male.

Discussion of Findings

The analysis of historical trends in physics performance at Zuarungu Senior High School, as presented in Research Question One, reveals fluctuations in the number of students achieving different grades over the years. This finding is consistent with previous research that has reported mixed results regarding gender differences in physics performance. While some studies have found no significant gender disparities, others have noted subtle variations with male students occasionally outperforming their female counterparts (Lindberg *et al*., 2010) [20].

Moreover, the differences in performance between male and female students, as explored in Research Question Two, reflect the nuanced nature of gender disparities in physics education.

Females generally have a slightly higher count in the A1-C6 and D7-E8 grade categories, suggesting potentially better performance in these categories, while males have a higher count in the F9 grade category, indicating potentially better performance in this category. These findings align with existing literature highlighting the influence of classroom dynamics, teaching strategies, and societal expectations on gender disparities in physics performance (Brewe *et al*., 2010; Perez *et al*., 2014) [2, 24].

The fluctuating trends over time and the differences in performance between male and female students underscore the need for targeted interventions to promote gender equity in physics education. Recommendations from the literature, such as implementing gender-sensitive teaching practices, promoting diverse role models, and creating inclusive learning environments, are pertinent in addressing these disparities (Lock & Hazari, 2019; Perez *et al*., 2014) [24, 19]. By incorporating evidence-based strategies informed by both the research findings and the existing literature, educators and policymakers can work towards fostering a more equitable and inclusive environment for all students in physics education.

Conclusion and Recommendations

The research study examined historical trends and differences in physics performance between male and female students at Zuarungu Senior High School in the Upper East Region. The analysis revealed fluctuations in performance over the years, with females generally showing a slightly higher count in the A1-C6 and D7-E8 grade categories, while males had a higher count in the F9 grade category. These findings are consistent with previous research indicating mixed results regarding gender differences in physics performance.

The study concludes that gender disparities in physics performance exist at Zuarungu Senior High School, with variations in performance trends and outcomes between male and female students. These disparities highlight the need for targeted interventions to promote gender equity in physics education. Implementing gender-sensitive teaching practices, promoting diverse role models, and creating inclusive learning environments are recommended strategies to address these disparities.

Recommendations

Based on the conclusion from the findings, the study recommends the following:

- There should be an implementation of gender-sensitive teaching practices to address biases and promote equitable learning opportunities for all students.
- Diverse role models in physics must be promoted to inspire and encourage female students to pursue physics-related careers.
- There should be a creation of inclusive learning environments that accommodate diverse learning styles and preferences.
- Professional development opportunities should be provided for educators to enhance their awareness of unconscious biases and improve their teaching strategies.

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